REMARKS

Further to the Office Action mailed October 2, 2009, Applicant respectfully requests reconsideration.

Allowable Subject Matter

The Examiner has indicated that claim 21 is allowed and that claims 12 and 19 would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Double Patenting Rejection

Claim 10 is objected to as being a substantial duplicate of claim 21. Applicant respectfully submits that this rejection is moot based on the amendments to independent claim 1, submitted herein, from which claim 10 depends. Accordingly, Applicant respectfully requests that this rejection be withdrawn.

In the Claims

Applicant has amended the claims and claim 1 now incorporates subject matter of former claims 2 and 5 (now canceled) and of claim 8, and has been amended to recite that the reaction gas contains at least one carbon-precursor hydrocarbon “selected in the group of propane, butane, propylene and ethane,” support for which is found at least at page 8, line 25 to page 9, line 2 of the originally filed specification. In addition, claim 1 has been amended to recite that the method is characterized by measuring the content in the effluent gas of at least one compound selected from “allene and propine,” and the process is controlled by adjusting at least the flow rate of “the carbon-precursor hydrocarbon” admitted into the oven “to maintain the measured content at a substantially constant value,” support for which is found at least at page 20, lines 32-35, original claim 1 and example 9 of the originally filed specification.

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Claim 8 has been amended to recite that "the carbon-precursor hydrocarbon" is diluted in methane "or in an inert gas," support for which is found at least at page 6, lines 21-26 of the originally filed specification.

Thus, Applicant respectfully submits that no new matter has been added by the amendments to the claims submitted herein.

Obviousness Rejections Under 35 USC §103

Claims 1 - 4, 6 - 9, 11, 13, 15, 16 - 18 and 20 stand rejected under 35 U.S.C. §103(a) as being unpatentable over US Patent 6,001,419 to Leluan in view of US Patent 6,210,745 to Gaughan and further in view of "Formation of Pyrolytic Carbon During the Pyrolysis of Ethane at High Conversions," by Glasier. Applicant respectfully traverses.

Claim 1, as amended, recites a method of controlling the process of densifying at least one porous substrate with pyrolytic carbon by chemical vapor infiltration. The process includes admitting a reaction gas "containing at least one carbon-precursor hydrocarbon selected in the group of propane, butane, propylene and ethane" and measuring the content in an effluent gas "of at least one compound selected from allene and propine." The process is controlled by "adjusting at least the flow rate of the carbon-precursor hydrocarbon admitted into the oven to maintain the measured content at a substantially constant value."

Leluan is directed to a method of chemical vapor infiltration with variable infiltration parameters for accomplishing a densification process. (Abstract). Leluan discloses that it is necessary to adapt the infiltration parameters throughout the densification process as a function of changes in the porometry, i.e., the size and shape of the internal pores of the substrate, as the pores are being filled. (Col. 4, lines 27-28). The variation of parameters, for example, temperature, pressure, gas flow rate, or gas retention (or transit time), is controlled in a predetermined manner and not as a function of a content in the affluent gas, i.e., in "real-time," as in the present application.

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The Examiner acknowledges that Leluan "fails to disclose controlling the process by measuring the contents in the effluent gas." (Office Action, page 5). According to the Examiner, however, "Gaughan discloses controlling a vapor deposition process by using a residual gas analyzer" to "improve real time monitoring of the process" and that it would have been obvious to modify Leluan to "analyze the effluent gas to control the process" as, according to the Examiner, "taught by Gaughan." (Office Action, page 6.)

Gaughan is directed to a surface coating process in which the chemical vapor in the chamber is monitored. (Col. 2, lines 10-13). According to Gaughan, there is a correlation between the amounts and ratios of various gases in a deposition chamber and the amount of material that has been deposited. (Col. 3, line 25 - col. 4, line 8). Gaughan teaches that a residual gas analyzer (RGA) can be used as a quality control system to monitor the surface coating process. (Col. 4, lines 8-47). Specifically, predetermined parameters are implemented to deposit a film and a resulting gaseous environment is measured. (Col. 6, lines 8-13; Fig. 3, steps 76, 78). The gaseous environment is measured and compared to an expected value range based on the amount of material that was meant to be deposited. (Col. 6, lines 14-20; Fig. 3, steps 80, 82). If the measured gases fall within the range, then the amount of deposited material is acceptable. If, however, the measured gases are out of range, then the amount of material that has been deposited is not acceptable and, therefore the process is outside of specifications.

Applicant notes that Gaughan is related to a surface coating process, and more particularly, to forming a TiN film onto a surface. Gaughan, however, does not relate to a pyrolytic carbon densification process as does Leluan and the present application. As set forth in the present specification, to successfully complete the process of densification of at least one porous substrate with pyrolytic carbon by chemical vapor infiltration, the reaction gas has to reach the internal porosity of the substrate before forming the pyrolytic carbon deposit. As also explained in the present specification, the infiltration process is greatly influenced by the progressive densification of the porous substrate, i.e., the progressive filling of the pores of the substrate.

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As Gaughan is related to an external surface coating process, Gaughan does not deal with the problems of filling up the pores of a porous substrate due to changes in porometry, as dealt with by Leluan, as such a problem is necessarily absent, and not an issue, in a surface coating process.

The Examiner acknowledges that Leluan in view of Gaughan fails to disclose measuring the content of allene, propine and benzene in the effluent. (Office Action, page 6). The Examiner submits, however, that Glasier discloses formation of pyrolytic carbon using ethane and discloses that the amount of benzene in the effluent gas relates to the carbon deposition and that it would have been obvious to control deposition by measuring the benzene in the effluent gas.

Applicant respectfully submits that maintaining "the measured content at a substantially constant value," as recited in claim 1, as amended, is not taught or suggested by the cited combination of references. Essentially, Applicant understands that the Glasier reference has been cited as teaching this limitation.

Glasier also relates to a surface coating process and to the study of the deposition of a pyrolytic carbon coating on quartz, i.e., a non-porous substrate, using ethane as a precursor. (Page 16, Right Col., last paragraph). According to Glasier, there is a correlation between the rate of pyrolytic carbon formation and the benzene concentration in a reactor. According to Applicant's review, however, the only teaching of Glasier with respect to benzene is that, in a surface coating process, the higher the benzene concentration in the reactor, the higher the deposition rate.

Glasier, however, only teaches that the benzene concentration relates to the deposition rate in connection with a CVD process, namely the formation of the coating film on the surface of a substrate. Even assuming that maintaining the content of benzene concentration at a constant value could assist in maintaining a constant deposition rate, as suggested by the Examiner, there would then be no relevance with respect to a CVI process. As the Examiner has noted, a CVI process differs from a CVD process in that it aims at depositing a material inside a substrate (within the porosity of a substrate) rather

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than on the surface of a substrate. In the case of a CVI process, maintaining a constant deposition rate would result in a premature blocking of the access to the internal porosity of the substrate. Even so, there is no teaching or suggestion that can be found in Glasier that a correlation is identified as between the deposition rate and a CVD process and the measured content of C_3H_4. Further, there is no teaching or suggestion to be found in Glasier that the content of the compound in the effluent gas is maintained at a substantially constant value by varying the flow rate of the carbon-precursor polycarbon, as is recited in claim 1.

Applicant respectfully submits, for at least the foregoing reasons, that independent claim 1, as amended, is patentable over the cited combination of Leluan, Gaughan, and Glasier. As claims 3, 4 and 8 - 12 depend, either directly or indirectly from claim 1, it is respectfully submitted that these claims are also patentable over this cited combination of references.

Claims 5 and 14, now canceled, stand rejected as being unpatentable over Leluan in view of Gaughan and Glasier and further in view of “A Reduced Reaction Model for Carbon CVD/CVI Processes” by Birakayala. As claim 1 has been amended to incorporate the subject matter of canceled claim 5, Applicant traverses the rejection of claim 5 as now being applied to claim 1.

Applicant submits that Birakayala does not remedy the deficiencies of Leluan, Gaughan and Glasier with respect to independent claim 1, as amended.

Birakayala is related to the densification of a porous carbon fibrous substrate by deposition of carbon within the pores of the substrate. (Page 675, Introduction, first sentence). Birakayala discloses a reaction model for a CVD/CVI process to predict the pore geometry changes with respect to time and gas space kinetics are a component of the model. (Page 676, left column, bottom 5 lines). A total of 47 reversible reactions involving 19 species are identified with a reference to the molecule C_3H_4 appearing at lines 16 and 17 of Table I. (Page 676). In order to build a useful model, a smaller set of the

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most relevant reaction mechanisms is selected. (Page 676, right column, last two lines to page 677, left column, line 1). The dominant species are identified as acetylene, benzene and ethylene. (Page 677, left column, line 16-18 and right column, lines 9-12).

The Examiner maintains that Leluan in view of Gaughan and Glazier discloses controlling the process by adjusting the flow rate of the gases in response to effluent gas concentrations but fails to disclose measuring the amount of allene and/or propine content. The Examiner asserts that Birakayala "explicitly discloses the by-products of the CVI process and discloses that the amount of C_3H_4 can be measured." (Office Action, page 4, lines 4 and 5). The Examiner further maintains that Birakayala discloses allene and/or propine are known reaction products during the formation of carbon during an infiltration process and therefore "taking the references collectively," it would have been obvious to modify Leluan in view of Gaughan and Glasier to adjust the process parameters in response to the allene and/or propine concentration "because Birakayala discloses such is present in measurable quantities in the affluent gas of a CVI carbon densification process." (Office Action, page 8).

Applicant respectfully disagrees and can find no teaching within Birakayala to measure the content of C_3H_4 in an effluent gas in order to control the process. Birakayala provides a detailed discussion about gas phase kinetics, surface kinetics and pore closure models that can be used to predict deposition profiles within the pores. With respect to the gas phase kinetics, Birakayala mentions that the complete mechanism is made up of 47 reversible reactions with 19 species. (Page 676, right column, section gas phase kinetics, first paragraph, lines 14-15). There is a reference to C_3H_4 in Table 1 and Fig. 2 but Applicant can find no indication or suggestion that the densification process could be controlled as a function of the C_3H_4 content in the affluent gas.

Further, the Examiner has failed to show why, when considering Birakayala, one of ordinary skill in the art would understand that the content of C_3H_4, among the 19 identified species, would be critical, whereas, on the contrary, Birakayala directs the reader's

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attention to the dominant species, i.e., acetylene, benzene and ethylene, which do not include C_3H_4.

As above, Gaughan and Glasier are directed to forming a coating on the surface of a substrate. In a densification process, in contrast to a surface coating process, the changes in porometry, namely the progressive closure of the pores of the substrate greatly influences the process, as discussed above. This is reiterated in Birakayala because the pore closure model is one of the three components of the overall process model.

Similar to the arguments submitted above, a pore closure model, as described by Birakayala, is completely irrelevant to an external surface coating process such as described by Gaughan and Glasier. One of ordinary skill in the art, when implementing a surface coating process, has no use for the teachings related to the problem of controlling a densification process as described by Birakayala.

Assuming, without agreeing, that the combination of these references is proper, however, Applicant respectfully submits that claim 1, as amended, is not rendered obvious by the cited combination of references for at least the reason that there is no teaching or suggestion of controlling a densifying process using a reaction gas containing at least one carbon-precursor hydrocarbon selected "in the group of propane, butane, propylene and ethane," measuring the content in the effluent gas "of at least one compound selected from allene and propine" and adjusting the flow rate of the carbon-precursor hydrocarbon to maintain the "measured content at a substantially constant value," as recited in claim 1.

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In view of the foregoing, Applicant believes the pending claims are in condition for allowance and a notice to this effect is earnestly solicited. The Examiner is encouraged to telephone the undersigned attorney to discuss any matter that would expedite allowance of the present application. The Examiner is hereby authorized to charge any fees due to this submission, or credit any balance, to Deposit Account No. 23-0804.

Respectfully submitted,

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Date: December 23, 2009

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